THE DECLINE OF THE NATIVE FISHERIES OF LAKES KYOGA AND VICTORIA AND THE IMPACT OF THE NILE PERCH, *LATES NILOTICUS* ON THESE FISHERIES

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ABSTRACT

There has been a decline almost to the total disappearance and in some cases apparently the extinction of most of the native fish species of Lakes Victoria and Kyoga since the development of the fisheries of these lakes begun at the beginning of this century. The Nile perch, *Lates niloticus*, a large voracious predator which was introduced into these lakes about the middle of the century along with several tilapiine species is thought to have depleted stocks of other fish. But other factors, such as overfishing, changes in the habitat which can result in fish kills or affect breeding and recruitment, plus competition with other species, appear to have contributed to the diminution in the stocks of other fish.

The available information indicates that by the time the Nile perch was established, the stocks of the native tilapiine species had been reduced by over fishing. The *Labeo victorianus* fishery had similarly been destroyed by intensive gill netting of gravid individuals on breeding migrations. *L. niloticus* is however, capable of depleting the stocks of species which have disappeared and could have consumed the remnants - thus preventing their recovery. It is also directly responsible for the decline in the populations of the haplochromine cichlids which were abundant over most of these lakes when it was established. The native tilapiine species were also affected by the introduced species which have similar ecological requirements.

INTRODUCTION

The species composition of the fisheries of Lakes Victoria and Kyoga has changed from that which prevailed at the beginning of this century when their development started. The earliest surveys of these lakes (GRAHAM 1929, WORTHINGTON 1929) show that tilapiine species, particularly *O. esculentus* (Ngege) and *O. variabilis* (Mbiru) were then the most important commercial species. Others included: *Protopterus aethiopicus* (Mamba), *Bagrus docmac* (Semutundu), *Clarias mossambicus* (Male), *Barbus* species (Kisinja), *Mormyrids* (Kasulubana) and *Schilbe mystus* (Nzere). *Labeo victorianus* (Ningu) formed the most important commercial species along the affluent rivers of the Lake Victoria basin (CADWALLADR 1969). Haplochromine cichlids (Nkejje) and *Engraulicypris argenteus* (Mukene) were abundant but, because of their small size, they were not exploited on a commercial scale.

The fisheries of Lakes Victoria and Kyoga are now dominated by two introduced nilotic species; the predatory, Nile perch, *Lates niloticus* and the herbivore *O.nilotica* (Figures 2 & 3). The small cyprinid *E. argenteus* now features prominently among commercial catches in Lake Victoria and is abundant in Lake Kyoga (OGUTU-OHWAYO 1984a). The originally important tilapiine species have virtually disappeared and even the haplochromine cichlids which were until recently the most abundant species group are disappearing at a very rapid rate and are virtually absent from Lake Kyoga and some parts of Lake Victoria. The *L. victorianus* fishery has also collapsed.

The Nile perch is a large, voracious predator capable of feeding on a wide size range of different types of fish. There is a widely held view that it is responsible for the disappearance of species from Lakes Victoria and Kyoga. But other factors such as overfishing, changes in habitat which can cause the death of the fish or affect recruitment, and competition for available resources, particularly between the native and introduced tilapiine species could have contributed to the diminution in stocks of certain species. This paper is intended to review the events which have contributed to the collapse of the native fisheries of Lake Kyoga and the role of the Nile perch.

CHANGES IN THE FISHERIES

The original state of the fisheries of Lake Victoria and Lake Kyoga were documented by GRAHAM (1929) and WORTHINGTON (1929). Subsequent changes have been examined by BEVERTON (1959), GARROD (1961a, 1961b), JACKSON (1971), FRYER and ILES (1972), FRYER (1973), BENDA (1979, 1981), MULLER & BENDA (1981), TWONGO and OGUTU-OHWAYO (1979) and OGUTU-OHWAYO (1984). The *Labeo victorianus* fishery has been analysed by CADWALLADR (1965, 1969). FRYER (1984) gives an outline of these changes.

Tilapiine cichlids provided the basis for the most important indigenous fisheries of Lakes Victoria and Kyoga. On Lake Victoria the tilapia fishery of the Nyanza (formerly Kavirondo) Gulf is the best documented. Its history is illustrated in Figure 4.

The earlier fisheries were mainly at subsistence level. The fishing gear consisted of locally made basket traps, hooks, and seine nets of papyrus. The fishing effort was low and caused little damage to the fishery.

Fishing effort began to increase when gill nets were introduced in 1905. This was augmented by improved communication such as the extension of the railway to Kisumu in 1908 which gave access to new markets. There was an increase in population and urban centres which resulted in a higher demand on the fishery. This caused a decline in catch rates from the initial 25 to about 7 fish per net by 1920. This rapid decline of the most important commercial species prompted the first fishery survey of the lake in 1928. On the basis of resulting recommendations the first and perhaps the only attempt was made to manage the fisheries of Lake Victoria. The use of gill nets of less than 5 inches mesh size was prohibited in order to protect the breeding populations of *Tilapia*.

From 1930 to 1940 the industry began to expand again as markets and communication improved. The number of *Tilapia* railed from Kisumu to Nairobi increased by 300%. As a result of this increased demand the fishing effort increased and there was a rapid fall in catch rates from 7 to 2 fish per net. The fishery remained stable until after the (1939-1945) war when it again expanded. The fishing licences issued in Kenya alone increased from 35 to 60 thousand between 1949 and 1952 with a comparable increase in Uganda. By 1955, catch rates had fallen so much that it became unprofitable to use 5 inch nets. As a result some fishermen started trying out the smaller meshes of 41/2 inches in order to catch the unexploited length. This illegal transfer to smaller mesh nets initiated the collapse of the fishery because from this time onwards, the fishermen adopted the habit of shifting to smaller meshes whenever the catch in the larger ones decreased. As expected, the catch rate in the 41/2 inch nets was initially much better than that in 5 inch nets but the fishes caught were, of course, smaller. This made the 5 inch mesh regulation so hard to enforce that it was repealed in Uganda and Tanzania in 1956 and in Kenya in 1961. The only justification here was that the 41/2 inch nets would bring increased landings of *O. variabilis* and mormyrids which due to their small size were not previously cropped by the 5 inch nets. But this would not offset the loss of *O. esculentus* which was the most important commercial species. The 5 inch nets also gave a better yield for the non-cichlid species, *B. docmac, C. mossambicus, P. aethiopicus* and *Barbus*.

When the mesh restriction was removed, there was a temporary increase in catch rates which attracted more fishermen into the fishery but by 1959 the catch rates were again as low as when the mesh restriction was removed. Inevitably, the fishermen continued to shift to smaller mesh gill nets. By 1965, 5 and 41/2 inch nets were no longer widely used. In one area, for example 96% of the catch was from 31/2 and 4 inch nets and the remaining 4% from those of 11/2 to 3 inches (Fryer & Iles 1972).

The trend of shifting to smaller meshes following a decline in catch rates also occurred in Lake Kyoga. Here, unfortunately, there was no limit to the size of nets. As a result nets of 21/2 to 4 inches were freely used. Though the smaller meshes were meant for smaller species such as *Schilbe mystus*, they destroyed the larger ones by cropping immature individuals.

The gill net effort on Lake Kyoga increased in the 1940s when migrant fishermen from Kenya and Tanzania arrived. This was followed by a tremendous increase in fishing effort as indicated by a tenfold increase in the sale of nets over the nine years that followed. This resulted in a rapid fall in catch rates from 30 to 7 fish per net in some places. During the 1950s the stocks of tilapia appear to have been very low because most people turned to long lining to catch *B. docmac, C. mossambicus*, and *P. aethiopicus*. As a result the proportion of the native tilapiine species among commercial catches decreased (Fig.1). By 1957 only 20% of the landings were from gill nets as compared to 70% from long lines and 10% from basket traps. During the following year there was further shift to smaller meshes of 2 to 31/2 inches. This indicates that, as in Lake Victoria the larger meshes had become unprofitable to use on the diminishing stock of larger individuals. From the decline in catch rates, which indicate a reduction in abundance, it can be concluded that the collapse of the native tilapia fishery of Lakes Victoria and Kyoga was due largely if not wholly to ill-conceived fishing practices.

Another fishing habit which contributed to the collapse of the *Tilapia* fishery was the use of seine nets near the lake margins. The native tilapiine species construct nests in shallow waters near the lake margins for courtship. The dragging of the seine nets disrupted courtship behaviour. Some brooding females were also caught, which destroyed the parent together with either its eggs or young. Some seine nets were of small mesh and took heavy toll of juveniles in their nursery grounds inshore.

Between 1969 and 1977 the East African (now Uganda) Freshwater Fisheries Research Organization initially in collaboration with UNDP/FAO carried out a fish stock assessment survey of Lake Victoria. A comparison of the trawl catch data made during the survey in the Nyanza Gulf in 1976 with earlier records of 1969/70 showed a reduction in stock densities of the most important species by several factors. *Tilapia* species, *L. victorianus, Barbus*, mormyrids, and *S. mystus* were virtually absent. The only abundant species which were being fished at that time were haplochromine cichlids which contributed 34.1%, and *E. argenteus* 30.3% of the commercial landings in 1976. The tilapiine species contributed only 5.55%. By this time the Nile perch was not well established and comprised only 0.5% of the catch.

The state of *Labeo victorianus*, which formed the most important fisheries on the affluent rivers of Lake Victoria can be deduced from Figure 5. This shows clearly that this fishery had also diminished before the Nile perch was established in the lake. *L. victorianus* is a migratory species which lives in the lake but ascends rivers to spawn during the rainy season. The indigenous fishing methods which consisted of barriers and basket traps set mainly along the river did not have a deleterious effect on the stocks.

Fishing for *L. victorianus* took place during its upstream migration. Many gill nets were set near the mouths of rivers, effectively blocking them off from the lake, and many of the mature spawning adults were caught. Fish with ripe eggs were unfortunately regarded as delicacy. Not only were gravid adults, destroyed but the young of the few individuals which managed to spawn were taken prematurely in large numbers by deep trapping from the banks of the river and flood pools.

THE IMPACT OF THE NILE PERCH

Commercial catches and experimental fishing show that two groups of fishes were still abundant in many parts of Lake Victoria at the time the Nile perch was becoming established. These are the haplochromine cichlids and the pelagic cyprinid *E. argenteus*. In the Kenyan waters these two contributed 64.2% to the commercial landings in 1976.

Nile perch began to appear prominently among commercial catches in 1977 (Figure 5). As its proportions increased from 1% the total landings in 1977 to 68% in 1983, that of the haplochromine cichlids, which initially formed its main food, declined from 32.4% in 1977 to less than 1% by 1983, and are now no longer found among commercial catches. The absence of haplochromines in commercial landings cannot be attributed to a shift in fishing effort to the larger introduced species. Trawl catch data collected by the Kenya Fisheries Research Institute between 1977 and 1981, using small mesh coded which can catch the small haplochromine cichlids, showed a similar decline in haplochromine biomass from 45% of the total catch in 1978 to 1% by 1980 and haplochromines are now rare. During the same period, the proportion of *L. niloticus* in the trawl catch rose from 10 to 60% (Hughes 1983). In Uganda waters an increase in the trawl catch rates of *L. niloticus* from 5 to 137 kg per hour between 1981 and 1984 was similarly accompanied by a decline in that of haplochromine cichlids from 523 to 108 kg per hour (Okaronon *et al* 1984). It is certain that *L. niloticus* has depleted stocks of haplochromines in some parts of Lake Victoria because this had been its main food (Gee 1969, Okedi 1970).

The food and feeding habits of the Nile perch show that it is capable of depleting the stocks of the species that have disappeared. Many of these have been found among the stomach contents of the predator. It could, therefore, have eaten the remnants of the native species whose populations had already been reduced by overfishing and prevented then from recovering. *L. niloticus* and *O. niloticus* which dominate the areas from which the other species have disappeared grow to a much larger size than the native tilapiine species. When the introduced species became established, most fishermen switched to larger mesh gill nets to catch them. This reduced the fishing pressure on any remnants of the native species and should have helped them to recover. It is surprising that this did not happen. As the populations of *L. niloticus* and *O. niloticus* increased, those of the native species continued to decline.

The Nile perch exhibits considerable plasticity in its feeding habits by being able to switch to different types and sizes of prey. In Lakes Victoria and Kyoga both the type and size of prey ingested have varied with time. Since its introduction into Lake Kyoga, for example, it has shifted from one type of prey to another as earlier types have become scarce. Soon after its introduction haplochromine cichlids and small mormyrids were the main prey (HAMBLYN 1966). A few years later, the diet had shifted to include tilapiine species (GEE 1969). When OKEDI (1970) examined its food a small pelagic cyprinid, *E. argenteus* which had not been previously recorded as prey was even more prominent than cichlids. The predator has shifted further and apart from depending on *O. niloticus* and *E. argenteus*, it also feeds much on members of its own kind (OGUTU-OHWAYO 1984). In Lake Victoria large Nile perch, which would normally feed only on fish have also shifted from the original predominantly haplochromine diet (GEE 1969, Okedi 1970) and does not only depend heavily on *E. argenteus* and members of its own kind but also consumes the crustacean prawn *Caridina nilotica* (HUGHES 1983, OGARI 1984). These changes suggest that certain types of prey have become rare.

When the size of prey that can be ingested by the Nile perch is considered (Fig.6), it is clear that it is capable of ingesting many of the species that have disappeared. All sizes of the native tilapiine species are within its range of capabilities.

When the size of prey ingested by the Nile perch soon after its introduction into Lakes Victoria and Kyoga is compared with that about 15 years later, it shows that the predator can shift to smaller or lager prey as suitable sizes become scarce (Fig.6). Where it has been introduced, it has initially been selective, choosing certain types of prey apparently on the basis of their size and abundance. As suitable sizes become scarce it shifts to either smaller or larger prey. For instance, in Lake Kyoga, Nile perch of less than 60 cm have shifted to smaller prey, while larger individuals have shifted to larger prey. As a result the Nile perch has sequentially eliminated fishes of certain size groups from lakes where it has lived for several years.

The reduction in availability of suitable food is indicated by a corresponding deterioration in the condition of the predator and the increase in cannibalism. Changes in the condition factor of the Nile perch in Lake Kyoga over the years (Table 1) shows that it has deteriorated particularly during the piscivorous phase which suggests that suitable fish prey are scarce. The condition factor in the new habitat is, however, still higher than that in the native habitat from which it was introduced. The higher condition factor in the new habitats suggests that even at present levels of predation, the amount of food available is greater than in the native habitat.

THE INTRODUCED TILAPIINE SPECIES.

The other fish which upset the species balance of Lakes Victoria and Kyoga were the introduced tilapiine species. During the 1950s, before the Nile perch was introduced, three herbivorous tilapiine cichlids *O. niloticus, O. leucostictus* and *Tilapia zilli* were introduced into these lakes. These have some similarities in ecological requirements with the native species which might have caused competition. The native tilapiine species were habitat restricted with the smaller *O. variabilis* being more inshore than *O. esculentus*. When *O. leucostictus* and *T. zilli* became established they occupied the same habitat as *O. variabilis*. Some evidence for possible competition has been observed among these species (FRYER, 1961). *O. niloticus* possibly competed for the more open waters with *O. esculentus*. In many areas *O. niloticus* became dominant, apparently excluding *O. esculentus* (WELCOME 1966). Apart from *T. zilli*, the other species are all mouth brooders and feed on phytoplankton. They could compete for food and nursery grounds.

Of the tilapiine species only *O. niloticus* has persisted in Lakes Victoria and Kyoga. The parallel success of *O. niloticus* and the predatory Nile perch is difficult to explain but may be related to their origin. They are both native to Lake Albert, the Nile below the Murchison Falls, Lake Turkana, the Chad basin and rivers of West Africa. *O. niloticus* is likely to be less vulnerable to predation from the Nile perch than the indigenous tilapiines of Lake Victoria as it has lived with the predator for a long time. *O. niloticus* grows to a larger size, has a faster growth rate, is more fecund, has a longer life span and wider food spectrum than any of the other tilapiine species. This could be advantageous.

Lastly, it is worthwhile noting that *O. esculentus* and *O. variabilis* do not naturally occur anywhere with *O. niloticus*. Some tilapiine species have also been observed to hybridize, indicating that there is no complete genetic isolation between them. The possibility of competitive exclusion cannot be completely ruled out - *O. esculentus* and *O. variabilis* may have lost ground to *O. niloticus* as a consequence of competition.

DISCUSSION

The above account indicates that unregulated fishing and predation pressure contributed prominently to the decline in the native fisheries of Lakes Victoria and Kyoga. This was partly because those involved in the administration of those fisheries decided to neglect the advice of those best qualified to predict what was likely to happen to them. That the predictions were substantially correct can be seen from the results.

In the first attempt to manage the fisheries of Lake Victoria, a 5-inch mesh regulation was recommended in order to protect the breeding populations of *O. esculentus* (GRAHAM 1929). This meant that without such a restriction stocks would be damaged. The repeal of this regulation was, therefore, an initiation of the destruction of the *Tilapia* stocks. That this was the case can be deduced from the gill net selectivity of *O. esculentus* (Figure 7). The recommended mesh of 5-inches caught mature individuals, some of which had bred several times. The 4-inch nets caught some fish before they had matured and those with still smaller meshes caught predominantly immature individuals. The removal of immature fish reduces subsequent recruitment and, therefore, the abundance of the stock. Relaxation of the 5 inch mesh size regulation was, therefore, gross mismanagement of the fishery.

BEVERTON (1959) who assessed the state of the fishery after the relaxation of the mesh regulation made several predictions which later analysis of the fishery by GARROD (1960) proved to be correct. First, that there would be an immediate and a long-term increase in the catches of *O. variabilis* and probably *Mormyrus* for which the 5 inch mesh was too large. A further reduction in mesh size to 4 inches would however result in a temporary but not a long-term increase in catches of both these species. Secondly, there would be a short term increase followed by a decrease in the catch of *O. esculentus, Clarias* and *Protopterus*. Thirdly, in areas where *O. esculentus* was lightly fished, its stocks and those of *Bagrus* and *Barbus* would decrease. Lastly, the increased catches of *O. variabilis* and mormyrids would not offset the loss of the other species.

These predictions prompted the analysis of the fishery by GARROD (1960, 1961a, 1961b). On the basis of his observations GARROD made a useful recommendation similar to that of GRAHAM (1929) that a greater yield could be maintained by using 5 inch nets. This could preserve the biomass and standing crop and reduce the chances of biological overfishing. He also provided an alterative which could allow exploitation of *O. variabilis* by showing that a mixture of 70% of 5-inch with 30% of 41/2 inch nets could give a good yield. These recommendations were not followed. Instead it is quoted (GARROD 1961b) that an "FAO expert" visited the lake and showed that all was well with the fisheries and so these recommendations were neglected.

The collapse of the *Labeo victorianus* fishery was similarly caused by failure to prevent biological overfishing through intensive cropping of gravid individuals and juveniles. Conservation of this fishery necessitated prevention of fishing at the time of spawning migrations (CADWALLADR 1969). The entrance to the river and the river course should have been closed to fishing during spawning in order to protect the stocks and produce sufficient recruits. Similarly, the use of seine nets on the breeding grounds of *Tilapia* had detrimental effects on the stock and reduced recruitment.

It is usually assumed that fishery resources are renewable and have an enormous ability to recover from exploitation so that a decline in stocks due to fishing can be easily replaced by recruitment. However, this may not be possible even in very fecund species. Mouth breeding fish like the tilapiine and haplochromine cichlids are particularly sensitive to cropping. This has been shown recently by the response of haplochromine cichlids to exploitation.

Commercial trawling in the Tanzanian part of Lake Victoria reduced haplochromine populations rapidly causing a decrease in catch rates from 1753 kg/hr in 1976 to 680 kg/hr in 1982 (GOUDSWARRD & WITTE 1984). This is because, although they are usually regarded as one group, they consist of many species - now estimated to be over 300 (van OIJEN *et al* 1984). Each species has a limited range of ecological tolerance, a low standing stock and a low rate of turnover. Females produce few eggs which they carry in their mouth for protection and the young are similarly protected. For each brooding fish either caught or eaten, its young are also destroyed.

The debate that proceeded the appearance of the Nile perch in Lake Victoria and Lake Kyoga and the caution against the introduction is as old as the story of the gill nets starting from GRAHAM (1929) and WORTHINGTON (1929). Again subsequent warnings (Fryer 1960) were disregarded. The Nile perch was introduced and the results have been disastrous. The native fisheries of Lakes Victoria and Kyoga have not only been damaged but some species seem to have disappeared (BAREL *et al* 1985, OGUTU-OHWAYO 1984). These fisheries, formerly based on a wide range of species, are now evolving into one dominated by only three;*L. niloticus, O. niloticus* and *E. argenteus*. The fourth group comprising the haplochromine cichlids is being eliminated at a rapid rate and is already virtually absent from Lake Kyoga and some parts of Lake Victoria.

The establishment of the Nile perch has been accompanied by large increases in the quantity of fish landed (Figures 2 & 3), which has led some observers to think that this has vindicated the experiment of the introduction (STONEMAN and ROGERS 1970). This boom is however likely to be temporary and more so if the fishery is again mismanaged. A predator at the top of a food chain cannot sustain a high yield for a long time. It requires five units of prey to produce one unit of the predator. In Lake Victoria the present high yield is being produced through feeding on large quantities of previously little exploited haplochromines earlier estimated to form 80% of the biomass of fish in the lake (KUDHONGANIA and CORDONE 1974). Once these are depleted the Nile perch populations will decline. This is already happening in Lake Kyoga, where it has lived for a longer time. The proportion of *L. niloticus* in the commercial landings has decreased from a record of 59 per cent in 1973 to about 17 per cent in 1985 (Fig.2) and is now stperseded by that of *O. niloticus* which forms about 79 per cent as compared to 33 per cent in 1973. Populations of *O. niloticus* in Lake Victoria are also increasing (Fig. 3) and may in future supersede those of Nile perch. If this happens the Nile perch will, as in Lake Kyoga, feed more on *O. niloticus* which is an important commercial species and which, unlike the Nile perch, is more efficient in converting the primary energy source into human food.

In Lake Kyoga, Nile perch of less than 20 cm was observed to feed predominantly on invertebrates, those of 20-60 cm on *E. argenteus* and those of more than 80 cm almost exclusively on *O. niloticus* (Fig.8) (OGUTU-OHWAYO 1984). *L. niloticus* ald *O. niloticus* are the only abundant commercially exploited species in Lake Kyoga. *E. argenteus* though apparently abundant, is not commercially exploited. The Nile perch, by feeding on *O. niloticus* is destroying the only other commercially important species. It was, therefore, recommended that selective fishing for the Nile perch during the stage when it feeds on *O. niloticus* should be encouraged. Since the stocks of the haplochromines which were initially the important prey of the Nile perch in Lake Victoria are diminishing, and that of *O. niloticus* increasing in a pattern similar to that in Lake Kyoga (Figures 2 & 3), selective fishing for Nile perch in Lake Victoria should also be encouraged.

A second recommendation had been made to discourage the development of an *Engraulicypris* fishery on Lake Kyoga. The available information indicated that *E. argenteus* was likely to become even more important in the diet of the Nile perch. Reducing its stocks would increase predation pressure on *O. niloticus*. This recommendation cannot apply on Lake Victoria where the *Engraulicypris* fishery is well developed. Such consideration would have socio-economic effects particularly upon those fishermen who cannot afford the expensive fishing gear for Nile perch. The conversion of *E. argenteus* to Nile perch as a food also involves loss of energy. This fish is also sun dried and does not require firewood whose procurement often results in deforestation.

Since the possibility of a trawl fishery based on haplochromines on Lake Victoria may be abandoned, a suggestion may come up to direct this fishery on the Nile perch. In some areas where other species have been depleted, *O. niloticus* has increased. Both Nile perch and *O. niloticus* occupy the shallower waters inshore. A trawl fishery for Nile perch is likely to destroy *O. niloticus* and even if it is designed to be selective for the perch, it will interfere with breeding by destroying courtship nests. Similar problems are associated with the use of seine nets. Gill nets would, therefore, provide the best method of selectively fishing for the Nile perch.

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Table 1. A comparison of condition factor in *L. niloticus* in its native habitats with that introduced in Lakes Victoria and Kyoga: The figure in brackets shows the number of observations.

Lake	Year	Length Class of *Lates* (cm)			Source
		Under 20	20-42.9	Over 43	
Turkana	1969	-	2.03(2)	2.11(14)	Gee 1969
Albert	1969	1.90(10)	1.94(85)	1.92(5)	Gee 1969
Victoria	1969	2.09(79)	2.25(401)	2.65(208)	Gee 1969
Kyoga	1969	1.82(1)	2.19(12)	2.36(32)	Gee 1969
Kyoga	1982	2.20(370)	2.10(828)	2.17(1045)	Ogutu-Ohwayo 1984b